

NPDG Liquid Hydrogen Target: Design and Safety Features

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Target vessel

- Main vacuum
- Vent isolation chamber
- He and Ar gas

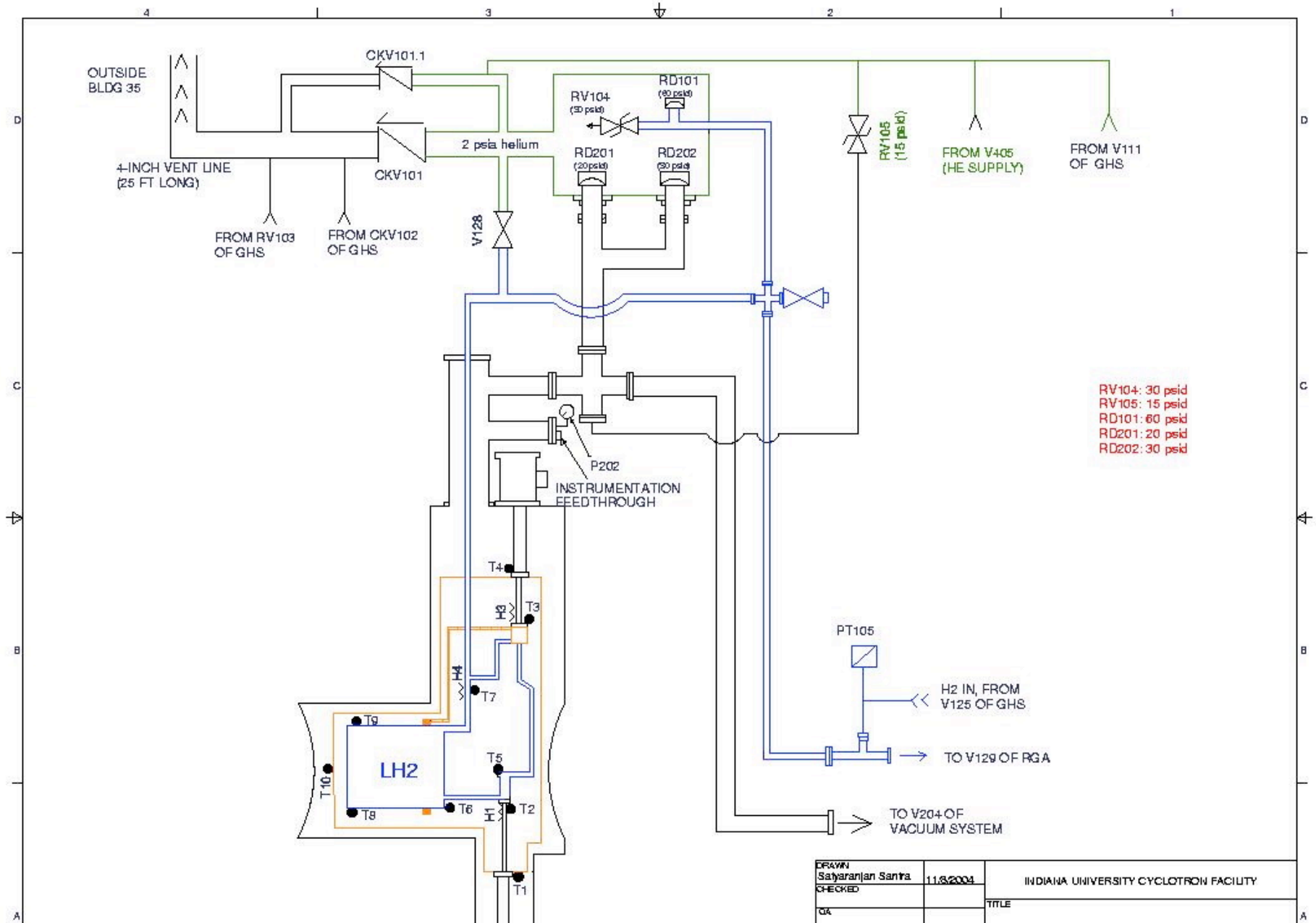
Design goals

1. Hydrogen SAFETY - target has to be absolutely safe to operate - it has to be in compliance with codes.
2. Target must absorb as much polarized cold neutrons as possible. \Rightarrow Target size of 30cm dia and 30cm length \rightarrow absorbs 60% cold n's.
3. To prevent neutron depolarization, requires para-hydrogen at $T \leq 17$ K \rightarrow 0.05% of LH_2 is in ortho state \rightarrow 1% of neutrons depolarized.
4. Suppress bubbles+safety \rightarrow $P > 1$ atm
5. Negligible attenuation for γ 's \rightarrow requires low Z (Al, Li plastic)
6. ^6Li -rich neutron shield
7. Cryostat must be non-magnetic.

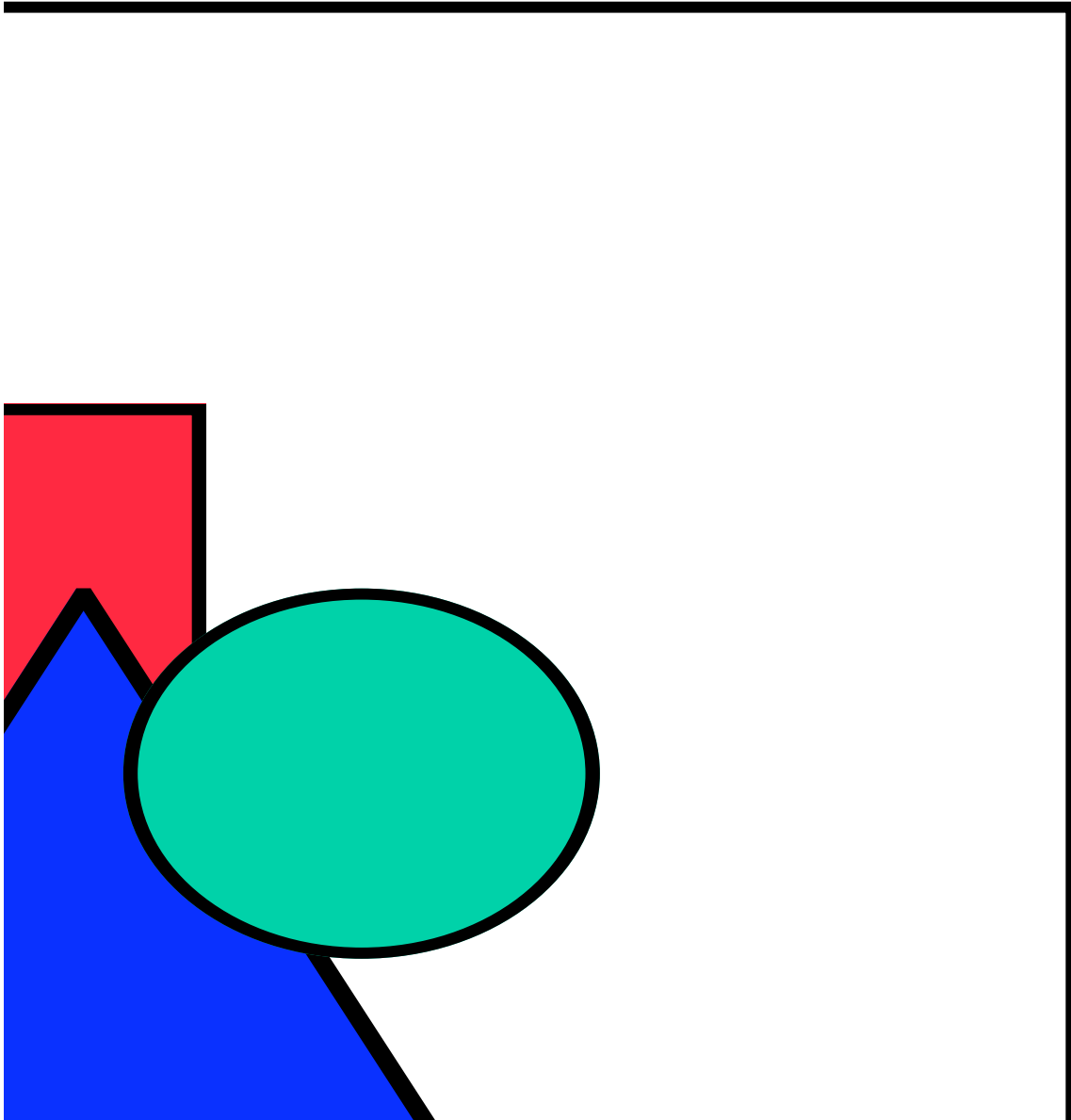
Main Guidance from Safety Reviews

1. No release of hydrogen into the experimental cave from failure of the main vacuum system or target vessel. Large volume of LH2 (~20 liquid liters)+location->vent system rather than thermosyphon
2. Application of the concept of “triple containment” to the LH2 in the cave (target vessel, vacuum, helium)
3. Capability to rapidly and safely vent LH2 on command in emergency situations (fire, etc.)

Cryostat and Vent System



LH2 target vessel



Welded 6061-T6 Al
pressure vessel

Shape from FEA
analysis

Conflat seals

Room temp P tests
to 90 psid

1.5" ID outlet

2 weld seams,
no windows

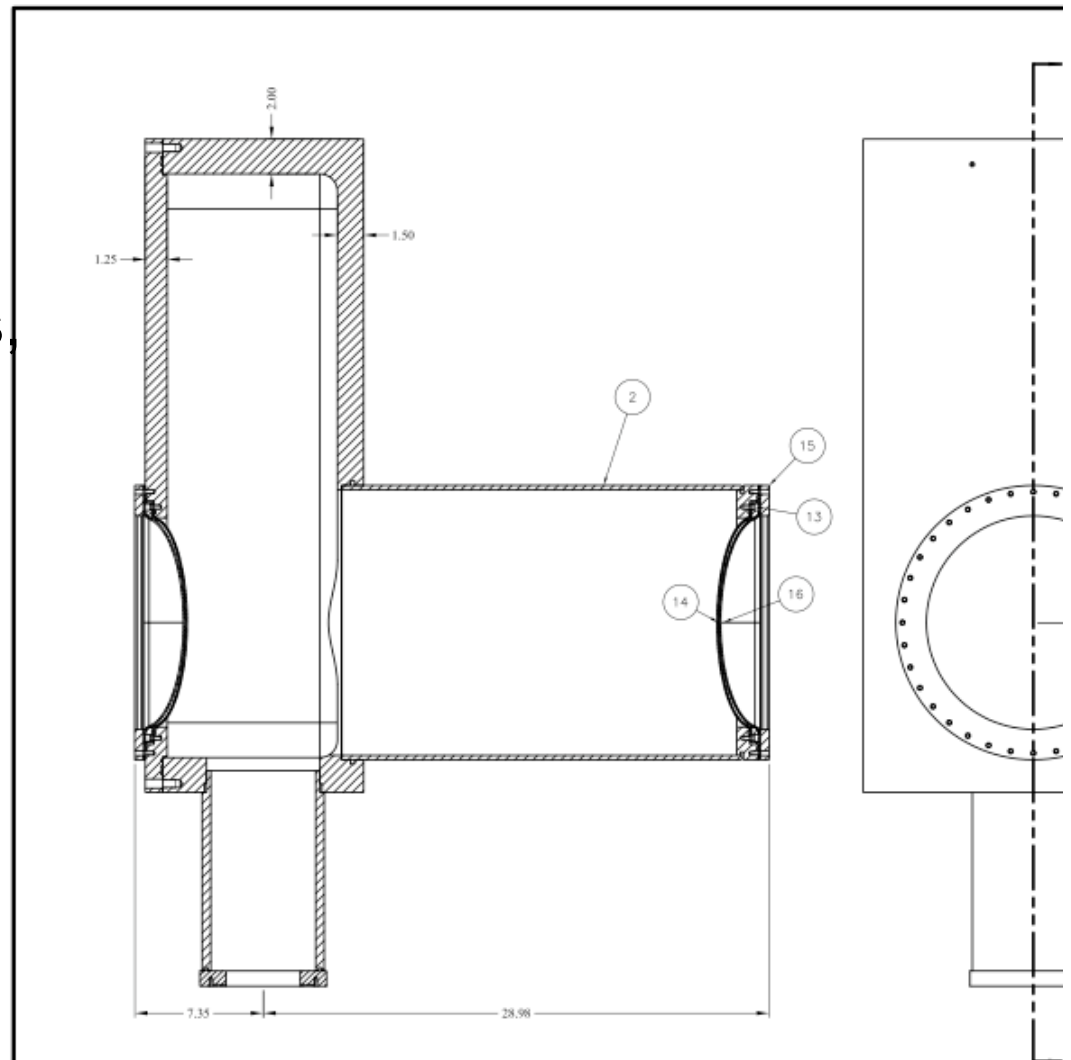
Main vacuum chamber

Box+cylinder+access plate. Box machined from single Al ingot, reduce welds

Windows: double-walled Al with stiffening rings

Helium gas between windows around all weld joints and o-ring seals using internal channel design

Vacuum+windows tested to 70 psid



Other Safety Features

- No wiring into LH2 part of cryostat
- Thick walls: no accidental punctures
- Two refrigerators: still a cryopump if one fails (GHS pumps valved off)



Target Vessel



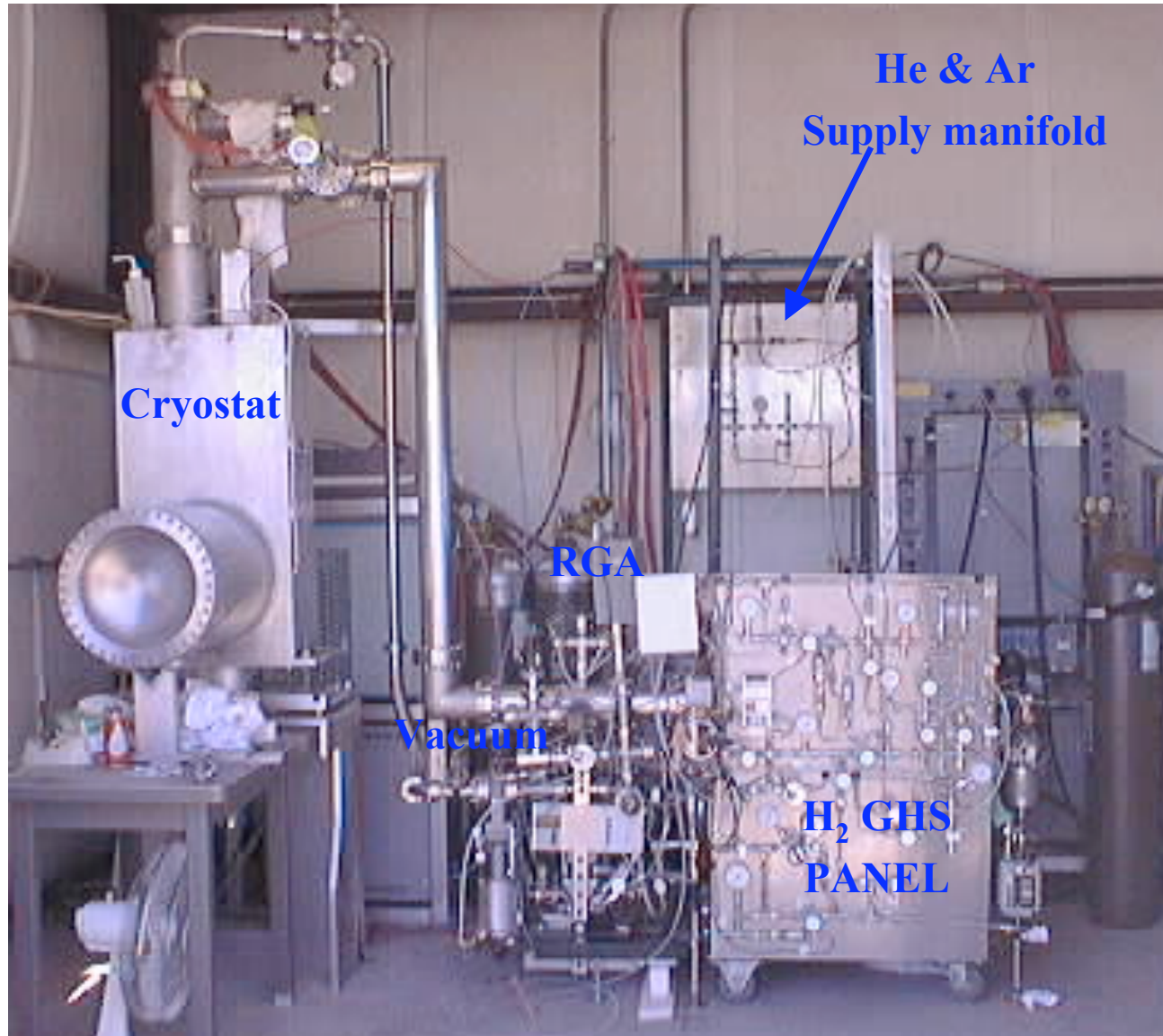
Main vacuum box with

Pressures: operating points, MAWPs, set points

Table 2. Pressures associated with LH₂ vessel and vacuum chamber and pressure set points.

Vessel					
	Normal operating pressure	Calculated maximum pressures (from ASME CODE)	Internal Maximum Allowable Working Pressure (from ASME CODE)	Pressure relief valve set points	Rupture disks set points
LH ₂ target vessel	15 psia	Internal: 159 psia External: 44 psia	60 psid	15 psid	60 psid
Main vacuum chamber	vacuum	Internal: 83 psia External: 40 psia	60 psid	Small relief valve: 15 psid	30 and 35 psid

Cryostat and gas handling system in the shed

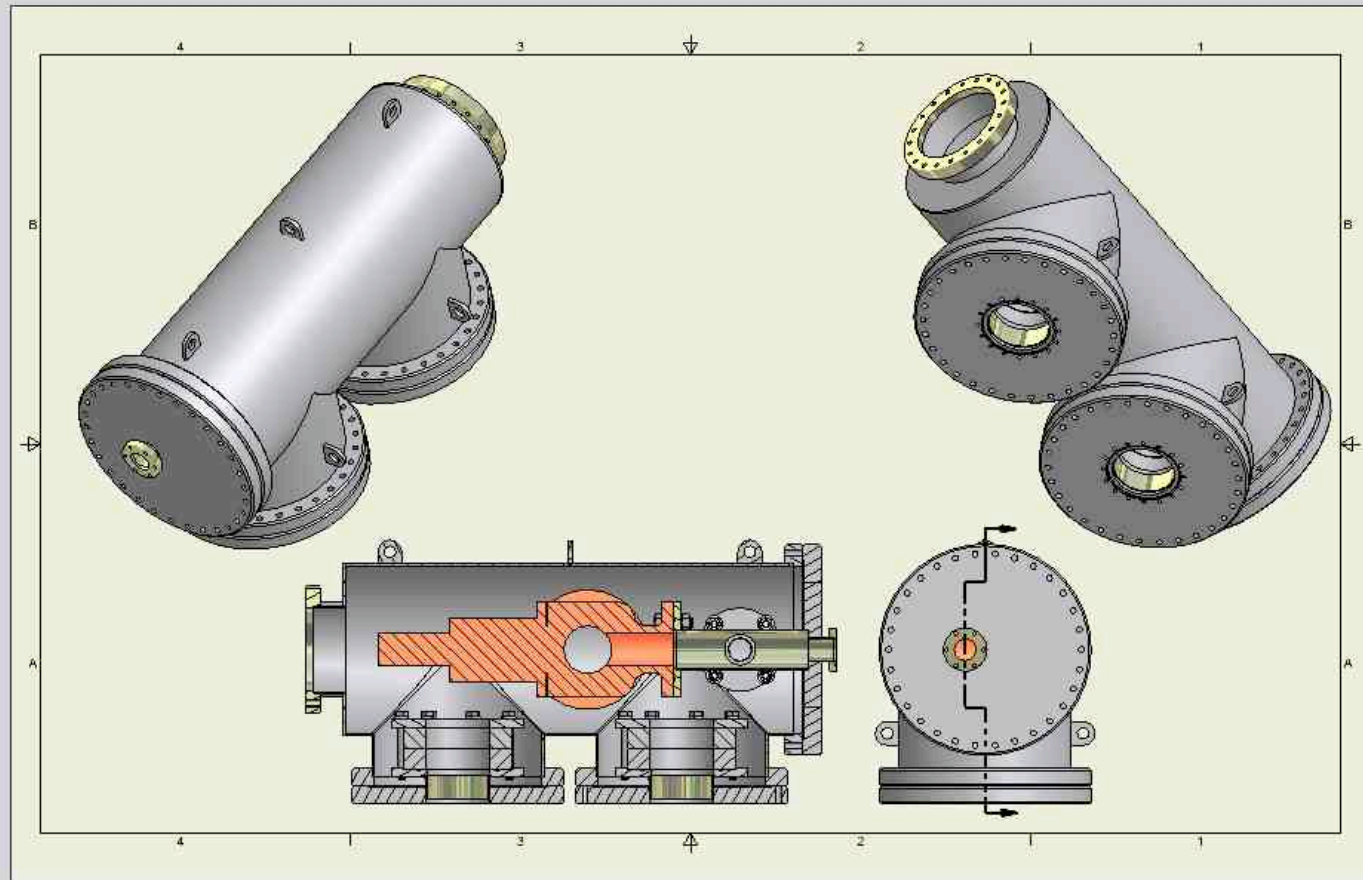


Vent Isolation Chamber

Allows the relief valves and burst disks to be contained in a clean He atmosphere

Chamber OK for internal pressure

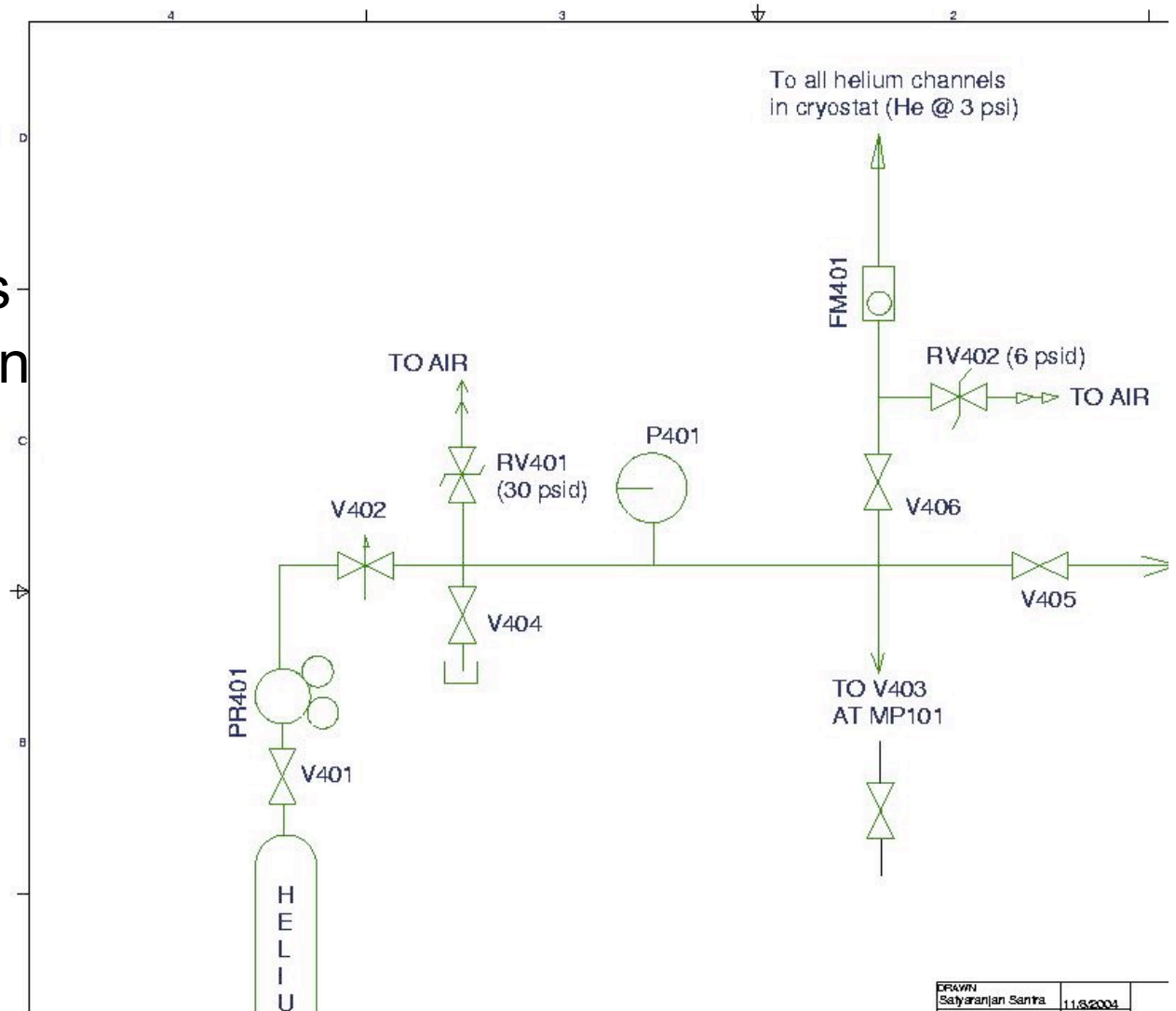
allows for easy access for adjustment/replacement



Helium for vent line, backing of rupture disks and vent valves, triple containment of LH2 chamber

Inert

Bleedback into target
From o-ring diffusion,
Burps of blowoff valves
do not introduce ignition
source to LH2



Argon supply to poison main vacuum for controlled target venting

Inert

Phase transition helps deliver heat to outside of vessel quickly

Recommended as safer than electrical heater around target

